"Here Today . . . Gone Tomorrow": A pH Investigation of Brigham Young University's 1987 Library Aquisitions

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Millions of library books are literally turning to dust because of acid. Only recently has the papermaking industry attempted to restore product permanency by producing acid-free and alkaline buffered papers. American publishers are showing a greater interest in such permanent papers. However, the transition to acid-free alkaline buffered paper by publishers has not been adequately monitored or surveyed. The 1989 pH investigation of 1987 acquisitions at Brigham Young University provides an in-house reference point for future monitoring and indicates that many publishers use acid-free and alkaline papers. The BYU survey and test model are designed for easy replication.

Millions of books in American libraries are threatened with destruction because they are printed on acidic paper. The acids come from chemicals that are either inherent in the pulp material, introduced during the papermaking process, or subsequently acquired from the environment. Over time these acids destroy cellulose fibers through oxidation, causing paper to become brittle, darkened, and weak. A process to neutralize woodpulp acids was developed in the late nineteenth century and nonacidic synthetic sizes have been available for nearly a half century.

The technology to produce nonacidic paper buffered with alkaline calcium carbonate was developed over forty years ago. In spite of these capabilities, the paper industry has been very slow to accept the new technology of alkaline or acid-free production. Until recently, publishers have been equally slow to demand durable quality paper.

In 1988, book-quality paper represented only 9 percent of the paper industry's total production.[1] The expense of converting to an alkaline system must be weighed against savings in production and environmental control costs. Experience has proved, however, that alkaline systems are cheaper to run, cause less equipment corrosion, and produce less

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harmful effluent.[2] Industry analyst Barbara Wortley succinctly characterizes the industry's reluctance to change systems in her comment, "traditional methods die hard."[3]

PAPER STANDARDS FOR PERMANENCY

The standard for paper permanence is defined by two basic factors—chemical and physical stability. These factors have a direct impact on the longevity and durability of paper.[4] Permanence refers to papers that should last at least several hundred years without significant deterioration under normal library use and storage conditions. An alkaline paper is an essential criteria for longevity and overall permanence. The physical characteristics of paper, including weight and tensile strength, determine its durability. A durable paper has high initial strength and resists wear and tear. Acidic paper does not have these qualities. Chemical and physical properties of paper are interdependent.[5]

Acidity and alkalinity are measured on a scale of 1–14 with 7 as neutral. Measurements on the descending scale of 7–1 are progressively more acidic and measurements from 7–14 are progressively more alkaline. In 1984 the American National Standards Institute (ANSI) adopted a minimum 7.5 pH specification for the publishing community.[6] A publisher's adherence to the standard is stated and/or symbolized by printing the infinity symbol within a circle on the title page verso. The term acid-free literally means that the paper is free of any acid; however, alkaline buffered paper below 7.0 pH is not necessarily acid-free.

THE PRESERVATION PROBLEM

Among Western nations, the problem of paper acidity is most acute in the United States.[7] Research has revealed that acid causes 85–95 percent of destruction in book papers.[8] More than 40 percent of major library collections are estimated to be unusable.[9] The Association of Research Libraries (ARL) estimates that 80 million books in North American research libraries are threatened with destruction. Within twenty years, this figure may rise to 114 million.[10]

Most modern book papers have an expected useful life span of less than fifty years.[11] Several major libraries, including the Library of Congress, report serious deterioration of their collections.[12] One estimate claims 530 million of the 3 billion pieces of paper in the National Archives are at risk.[13]

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Standards for alkaline and acid-free paper have been established but adherence to them is voluntary, making accountability nearly impossible. No official monitoring program for alkaline paper production or publishing use exists. In an attempt to determine preservation strategies, library surveys are increasing.[14] A University of California Libraries' study found 61 percent of their books measured less than pH 4.5, while a Yale University Library investigation found 87 percent of its collection less than pH 5.4.[15] However, a recent Columbia University survey discovered that 78 percent of its United States imprints published between 1987–1988 were alkaline.[16] Columbia's discovery may be indicative of a favorable trend in publishing. It certainly gives credence to a widely held assumption that a significant increase in acid-free or alkaline paper production has occurred over the past few years.

While proclaimed adherence to paper durability and longevity standards on title or verso pages has increased, particularly among academic publishers, discrepancies in these proclamations have been discovered.[17] In at least one study, paper declared alkaline proved acidic and others undeclared proved alkaline.[18] It cannot be assumed, therefore, that statements of compliance or assumptions regarding acidity are accurate.

THE PURPOSE OF THIS STUDY

The objective of the investigation reported here was to determine the percentage of 1987 alkaline or acid-free hardback and paperback American imprints purchased by the Harold B. Lee Library (an ARL member) at Brigham Young University (BYU). The BYU findings have the potential to corroborate or refute the Columbia University survey results and assumptions regarding alkaline book paper use. The reliability of acid-free or permanence statements in books and acid-free notations or qualifiers added to publisher's International Standard Book Numbers (ISBN) was also determined.

In addition, a primary purpose of the BYU study was to develop a simple but reliable survey method and statistical model that could be easily replicated in-house and at other institutions. The results of this investigation will provide a reference point for future surveys and collection monitoring at BYU. The study was conducted with the hypotheses that a majority of the titles would test alkaline, and that acid-free or paper permanence ISBN statements would prove accurate.

METHODOLOGY

Each year approximately 35,000 new books are added to the Harold B. Lee Library collection. This total includes both foreign and American, commercial and academic imprints. The population selected for investigation consisted of the commercial titles published in the United States in 1987. The year 1987 was selected because it was the most recent year to have its complete acquisition records loaded on the NOTIS online acquisition system when this study was conducted in March 1989.

This study did not include United States Government and academic press publications. The United States Government Printing Office is the nation's largest publisher and biggest user of acidic paper.[19] In contrast, academic presses use mostly alkaline paper for the major portion of their publications.[20]

Selection of individual books for testing involved a set of consecutive substeps: (1) generating a random numbers table, (2) determining the sample size and selection sequence, (3) generating a population list of book titles, (4) selecting specific books, (5) identifying catalog numbers (Dewey or LC), and (6) locating the book in the stacks.

A random numbers table was generated by using the SUCCESS program. The program picked from the table the number three for the start of the selection sequence and the number twelve for the order of selection. This means that beginning with the third title from the population list, every twelfth title was chosen for a total of 400 books. Selection of 400 books required more than one run through the population list using the "wrap-around" technique. Obtaining the 400 sample volumes required 2.25 wrap-arounds from the population list. The BYU Center for Statistical Research used the following equation to determine that a sample of 400 books would be sufficient for a 95 percent confidence interval.

A NOTIS terminal was used to select the population. Although book orders are not arranged by publication date or place of origin, a search for American 1987 titles was conducted without having to retrieve the full purchase record. A keyword search using the command, (1987.FXDDAT1.), identified all 1987 purchases.

In order to limit book selection to American publishers, it was necessary to eliminate foreign English-speaking cities that are publishing centers. This was accomplished by altering the search command to read: (1987.FXDDAT1.) NOT (London, Manchester, Oxford, Toronto, Sydney, Hong Kong). Although this did not exempt the few English titles published in other foreign countries, it did exclude most of them. The United States Government was not defined as a commercial publisher for this study. Its publications were excluded by adding "Washington, DC" to the list of cities. This search process did not distinguish between commercial and academic presses; that selection was conducted manually.

The keyword search for 1987 English-language publications identified 12,450 titles. Of these, an undetermined number of American government and foreign English imprints were still included. However, the complete list of 12,450 titles was not accessible by NOTIS. Only the first 5,000 imprints in order of purchase were available by computer. This fixed the total population available for any given year of surveying to 5,000. Using the every-twelfth book selection process, the population list was searched for the specific book titles to be tested. Each title selected was marked for later bibliographic identification on a BYLINE (BYU public access version of NOTIS) terminal.

The color reaction of the chlorophenol red solution is nearly immediate, within five seconds.

All pH testing was conducted in the stacks of the Harold B. Lee Library using a chlorophenol red indicator pen (the pens are available from Abbey Publications, Provo, Utah). The chlorophenol red solution is applied through a felt tip on the tail or foot edge (the permanent stain is less noticeable in this location) of the textblock. A single light stroke approximately one inch in length parallel to the case edges deposits enough solution for a reading.

The cut edge of the textblock provides a more accurate reading than the surface of a page because the cut edge allows direct access of the chemical to the interior fibers of the paper. Paper surface coatings and additives hinder absorption and can cause false test readings. Cut foredges of books provide easy access to acid impurities. The 1987 volumes included in this investigation were in circulation for less than eighteen months, which is not considered a long enough exposure to acid or other pollutants in the atmosphere to bias the test.[21]

The chlorophenol red pen provides three broad categories of acidic-alkaline measurement. The chemical changes color in contact with either acid or alkaline material. Acidic paper under pH 6.0 turns the test solution yellow (or colorless in some cases). Alkaline paper greater than pH 6.7 turns the chlorophenol red solution a bright purple (or occasionally pink). Papers in the range of pH 6.7 or greater may also be acid-free. The test pen is not specifically calibrated for a pH 7.0, but virtually all papers above that range are acid-free. Papers testing between pH 6.0-6.7 that contain a measurable positive alkalinity, but are not acid-free, show a grey color of various shades: yellow-grey at the bottom end and a purple-grey at the top of the measuring range.

$$n = \frac{p(1-p)Z^2}{B^2} \qquad n = \frac{.5(1-.5)2^2}{1^2} = 400$$

n = sample size
p = .5 (estimated proportion)
p(1-p) = formula for variance
B = Bound (for accuracy of estimate within 5%)
Z = Z score squared (1.96 for a 95% confidence level rounded to 2 which actually increases sample size over the statistical requirement)

FIGURE 1
EQUATION FOR DETERMINING SAMPLE SIZE
WITH A 95% CONFIDENCE LEVEL

$$\overset{+}{P\text{-}2} \quad \sqrt{\ } \quad \frac{P(1-P)}{n}$$

P = observed proportion
2 = Z score (1.96 rounded to 2)
n = sample population (400)

FIGURE 2
CONFIDENCE INTERVAL EQUATION

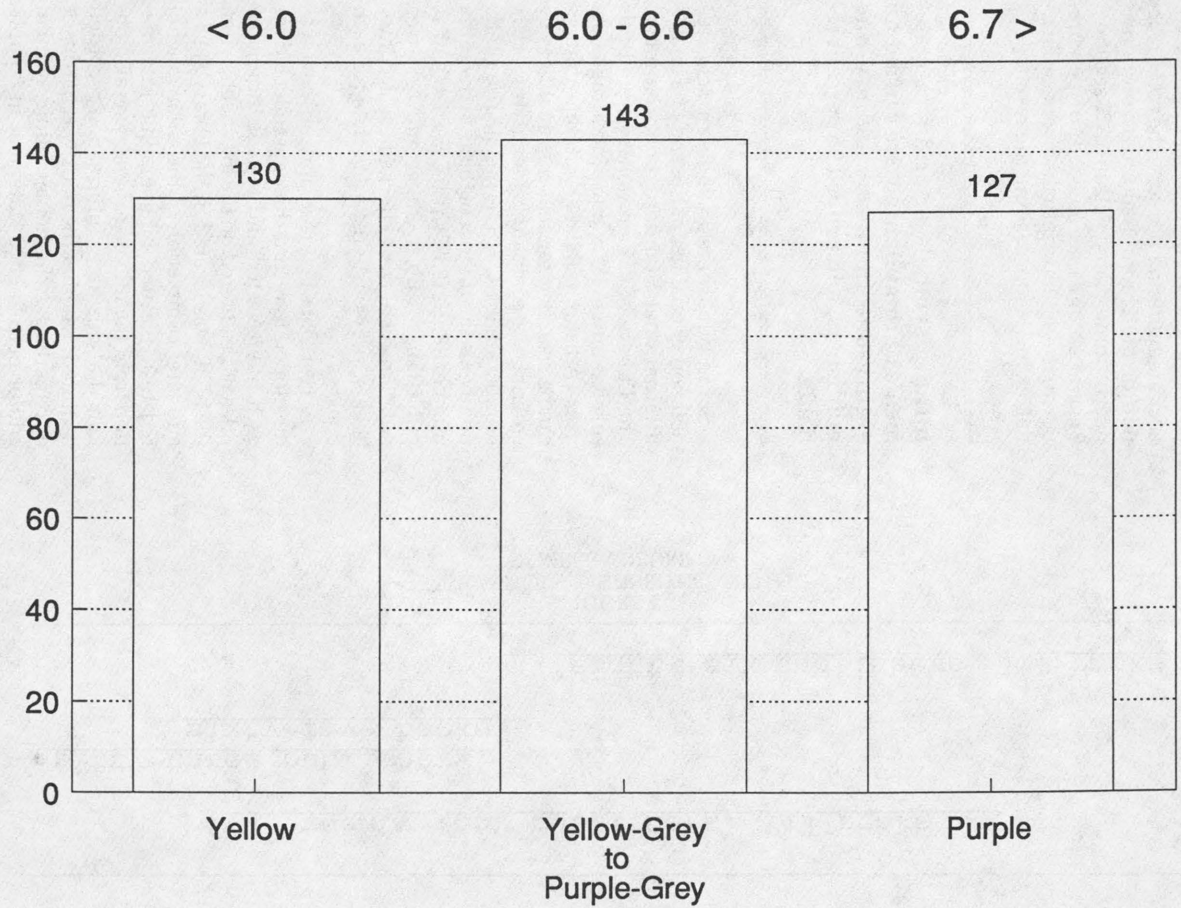

FIGURE 3
TEST DISTRIBUTION OF SAMPLE BOOKS

<6.0 6.0-6.7 6.7>

[twenty-four publishers, 143 books]

[fifty-three publishers, sixty-five books]

[eighty-six publishers, 192 books]

FIGURE 4
PUBLISHER'S DISTRIBUTION WITH SAMPLE VOLUMES

The pen is most effective at measuring one extreme or the other on the pH scale. The purple-grey color in the pH 6.0-6.7 range is distinctly unlike the purple of the pH 6.7 plus range or the yellow at the pH level below 6.0. The pen does not test for alkaline-buffering per se.[22] The color reaction of the chlorophenol red solution is nearly immediate, within five seconds. Several seconds are needed for penetration of the solution into the fibers and partial drying before reading the results.

Infinity symbols or acid-free statements of compliance were carried on eighty-one books by twenty-one publishers, and proved 96 percent reliable.

Some publishers include an acid-free notation or qualifier at the end of a book's International Standard Book Number. The Library of Congress has offered this service since 1985 and encourages its use.[23] A list of publisher's ISBN numbers can be searched for acid-free qualifiers by entering the company's identifying prefix number on a NOTIS terminal. The prefix number is the first set of digits in the ISBN number (e.g., 0-395 in 0-395-20360-0). A publisher's ISBN number and acid-free notation were then checked for accuracy against previously recorded data for each book.

A Test Data Log (see appendix A) was developed to record the data collected for each title selected and tested. Individual titles were entered on the log sheets when the book was located in the library stacks and after completion of the chlorophenol red test. Needed bibliographic information from the title page verso was also obtained at this time. Information recorded included: whether the book was hardback or paperback, whether an infinity symbol and/or permanence statement in compliance to ANSI standards was included on the title page verso, whether the publisher's ISBN designation included an acid-free notation or not, the publisher's name, and the actual results of the chlorophenol red test.

Data analysis was based on tabulation of all the Test Data Log information. The data were later coded on a "data list file" and loaded on the SPSS software program for computations. Ratio percentages (frequencies) were the computations of primary interest. These percentages indicated what portion of the sample were acidic or alkaline and identified the quantity and accuracy of permanence statements, ISBN qualifiers, and other collected data. Confidence intervals were computed by either SPSS or calculated with the equation below.

One promising discovery in the BYU investigation was that 78 percent of the paperback books tested alkaline.

DATA ANALYSIS

The random sample of 400 books included 163 publishing houses, 368 hardback and thirty-two paperback titles (see appendix B for individual test results). Infinity symbols or acid-free statements of compliance were carried on eighty-one books (20% of the sample) by twenty-one (13%) publishers. Symbols proved 96 percent reliable. Fifteen (9%) publishers listed the acid-free ISBN qualifier fifty-nine times with an accuracy of 93 percent. A total of four hardbacks, including two from one publisher, and one paperback were falsely labeled acid-free when they were actually acidic. These five volumes represented 4 percent of the 140 titles labeled acid-free or permanent and/or carrying ISBN acid-free qualifiers.

The chlorophenol red test found 130 (33%) books less than pH 6.0, 143 (36%) between pH 6.0-6.7, and 127 (32%) above pH 6.7. The 130 acidic and 127 highly alkaline books represent the opposite ends of the pH scale. The middle-range books tested alkaline, but were on the lower end of alkalinity (yellow-grey).

Among the 163 publishers in the BYU study, twenty-four (15%) produced 143 acid-free and alkaline books. The publishing trend appears to be that large firms produce both acidic and alkaline books with little concern for paper quality. No fewer than fifty-three (47%) of the publishers produced at least one of the sixty-five imprints (32.5% of the sample) with high acid content only. In contrast, eighty-six companies or organizations (53% of the total) published only alkaline volumes and each had at least one of the 192 alkaline books (48%) in the sample. Publishers producing only alkaline or acidic volumes within the sample were generally smaller and mid-sized corporations.

Out of the 270 titles that tested alkaline, only 140 (52%) contained an infinity symbol, an acid-free statement, or had an ISBN acid-free qualifier, and five of these books were mislabeled (lowering the actual percentage to 50%). One promising discovery in the BYU investigation was that twenty-five (78%) of the thirty-two paperback books tested alkaline. This counters the common assumption that *all* paperbacks are printed on acidic paper.

SUMMARY AND CONCLUSION

Comparison of test results from similar BYU and Columbia University sample groups reveal some significant correlations. The chlorophenol test results for 1987 American commercial imprints found that 67.5 percent of BYU's books and 65 percent of Columbia's were alkaline. The same sample groups tested 32.5 percent acidic at BYU and 35 percent at Columbia.[24] Both surveys found five books mislabeled as alkaline when in fact they were acidic.

Results for 1987 American commercial imprints found that 67.5 percent of BYU's books were alkaline.

There is a 95% confidence level that between 63–72 percent of the BYU statistical population (5,000 1987 U.S. imprints) is also acid-free or alkaline. The evidence from this study clearly indicates that a significant portion of American commercial trade publications are produced on acid-free or alkaline paper.

Publications produced on alkaline paper will not need deacidification or microfilming for preservation, thereby effecting a long-term cost savings for libraries and other institutions.[25] Alkaline and acid-free books may last for centuries rather than decades in ordinary library use, without significant deterioration.

Adherence to the ANSI standards by paper mills and publishers remains voluntary. Still, the March 7, 1989, decision by some authors and publishers to publish first editions of quality hardcover trade books on acid-free paper is encouraging. This decision could result in a 50 percent increase in acid-free publications.[26] It is perhaps indicative of a trend for larger publishing firms to join the ranks of the typically smaller or mid-size printers of alkaline materials. State and federal governments are also showing an increased interest in the use of permanent paper.[27]

Public interest and concern should be continued to help persuade the publishing community to use acid-free and alkaline paper in order to stem the flow of acidic paper into libraries. Replication of this study will contribute to the establishment of a monitoring program and the growing interest and concern for books of permanence.

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APPENDIX A. TEST DATA LOG*

# HB/PB†	ISBN #‡	PERM. STAT./ INFINITY Y / N§	ISBN A/F INDIC. Y / N‖	PUBLISHER#	ID#**	<6	6-6.7	>6.7††

* Each standard length data sheet contains fifteen entry lines.
† Space for the sequency number of each book and designation for hardback or paperback cover.
‡ International Standard Book Number.
§ Yes or No, whether a permanence statement or infinity symbol is included in title page verso.
‖ ISBN acid-free qualifier or notation, Yes or No.
\# Publisher's abbreviated name.
** Publisher's ISBN identifying prefix number.
†† pH reading.

APPENDIX B. TEST LOG DATA TABULATIONS AND DISTRIBUTION

Publisher	HB	PB	Permanence Statement/ Infinity Symbol	ISBN Acid-Free Notation	<6.0	6-6.7	>6.7
Abbe	1		1	1	1		
Ablex	2					2	
Academic	3		3	2	1	1	1
Addison-Wes.	2	1			1		2 \ 1pb
Alan R. Liss	2				2		
A. Whitman	1					1	
Allen Smith	1				1		
Allyn & Bac.	3				1	2	
Am. Assoc. of Cereal Chemists	1				1		
Am. Chem. Society	1					1	
Am. Math Society		1	1				1
AMA		1				1	
Apple Com.	1				1		
Appleton	2						2
Ardis	1		1			1	
Aspen	1						1
Assoc. for Educ. Comm.	1				1		
Atheneum	5					4	1
Avon			1		1		
Ballinger	1					1	
Bantam			1			1	
Barnes & Noble	1				1		

Publisher	HB	PB	Permanence Statement/ Infinity Symbol	ISBN Acid-Free Notation	<6.0	6-6.7	>6.7
Basic Bks.	1					1	
Basil Blkw.	1					1	
Beacon	1					1	
Birkhauser	1				1		
Blk. Sparrow	1					1	
Bookcraft			1		1		
P. H. Brooks	1						1
Business Pb.	1						1
CBI	1					1	
Camden	1		1				1
Capitol		1					1
C. C. Thomas	1				1		
Chelsea	8		7	4		7	1
Cold Spring		1			1		
Collins	1				1		
Computer Sci. Pr.	1						1
Computer Soc. Pr.		1			1		
Council for Foreign Relations	1						1
CRC	7				7		
Crown	3					3	
D. C. Heath	8	1	9	8		7	2/1pb
Dodd, Mead	1				1		
Doubleday	2	1				1	2/1pb
Dow Jones	3				1	1	1
Dryden	4				4		
Dutton	1				1		
Edwin Mellon	1			1		1	
Elsevier (NY)	2					1	1
Facts On File	2					2	
Fawcett		1					1
Fortress	1	1			1	1pb	
Franklin Watts	1				1		
Free Press	1				1		
Freeman	1						1
Fromm Intl.	1					1	
Gale	2				1		1
Garland	15		15	15		10	5
Globe Pequot	1					1	
Gloucester	1					1	
Greenwood	8		8	8		3	5
Guilford	3				1	1	1
Hackett	1						1
Hall, G. K.	4		4	2			4
Harcourt	2					2	
Harper & Row	12				5	5	2
Hastings	1						1
Henry Holt	3				3		
Holt, Rinehart	1				1		
Houghton	3				2	1	
Interweave	1				1		
John Knox	1					1	
Jones & Bartlett	1						1
Jossey-Bass	2					2	
Kendall/Hall	1					1	

Publisher	HB	PB	Permanence Statement/ Infinity Symbol	ISBN Acid-Free Notation	<6.0	6-6.7	>6.7
Knopf	3				1	2	
Lawrence Erlbaum	2				2		
Lea & Febiger	1					1	
Libraries Unlimited	4	1	1pb		2/1pb	3	
Lippincott	1					1	
Little, Brown	2						2
Longman	2	1			1		2/1pb
Lynne Rienner	2		2			1	1
Macmillan	10				7	2	1
Martinus Nijhoff	1					1	
McFarland	2		2			2	
McGraw-Hill	13	1			10/1pb	1	3
Mercel Dekker	2						2
Methuen	1				1		
Mitchell	1				1		
Morrow	1						1
Mosby, C. V.		1			1		
Multi-Lingual	1				1		
Nat. Educ. Assoc.		1				1	
Nelson Doubleday	1						1
New American Library	1				1		
N.Y. Literary Forum		1					1
Northland	1				1		
North Point	1						1
Orbis	1	2				1	2pb
Oryx	1		1	1		1	
Overlook	1					1	
Paradigm	1				1		
Paragon	1				1		
Parker	2					2	
Paulist Pr.	1						1
Pergamon	1				1		
Peter Lang	1					1	
Philosophical Library	1				1		
Pitman		1			1		
Plenum	4				1		3
Praeger	9		9	8		6	3
Prentice-Hall	25	2			11	3	13/2pb
Probus	6					4	2
Productivity	1						1
Pro-Ed.	1				1		
Prometheus	1					1	
Pruett	2				2		
Publishing Horizons		1				1	

Publisher	HB	PB	Permanence Statement/ Infinity Symbol	ISBN Acid-Free Notation	<6.0	6-6.7	>6.7
Putnam	3				1	2	
Que	1				1		
Quorum	2		2			1	1
Random House	1					1	
Rutledge & Kegan	2					2	
Sage	1				1		
St. Martins	6				4	1	1
Scarecrow	3					2	1
Scholars Pr.	2		2	1			2
Science Technology	1				1		
Scott, Foresman	2	1			2/1pb	1	
Scribners	1						1
Shambhala	1	1				2	
Simon & Schuster	1					1	
So. Western	1				1		
Springer	2				1		1
Starsong		1			1		
Sybex		1					1
Tab Books	4				1	1	2
Taylor & Francis	1					1	
Tom Doherty	1						1
Transaction	3				2	1	
Transnatl.	2					2	
Twayne	7		4	3	2		5
UMI	1		1	1			1
Ungar	1				1		
Van Nostrand	6	1				2/1pb	5
Viking	2				1	1	
Wadsworth	1					1	
Warner	1						1
Warren-Gorham	1						1
Weber Syst.	1				1		
West	1				1		
Westview	3	4	6	3		2/1hb	5/2hb
Wiley, John	21	1			3	8/1pb	11
Williams & Wilkins	1				1		
Wilson, H. W.	1						1
Wordware	1						1
The World Bank	1				1		
World Book	2				2		
Writer's Digest	2				2		
W. W. Norton	3				1	1	1
Year Book Medical	1					1	
Total	368	32	81	59	130	143	127